B EE 478

Power System Analysis

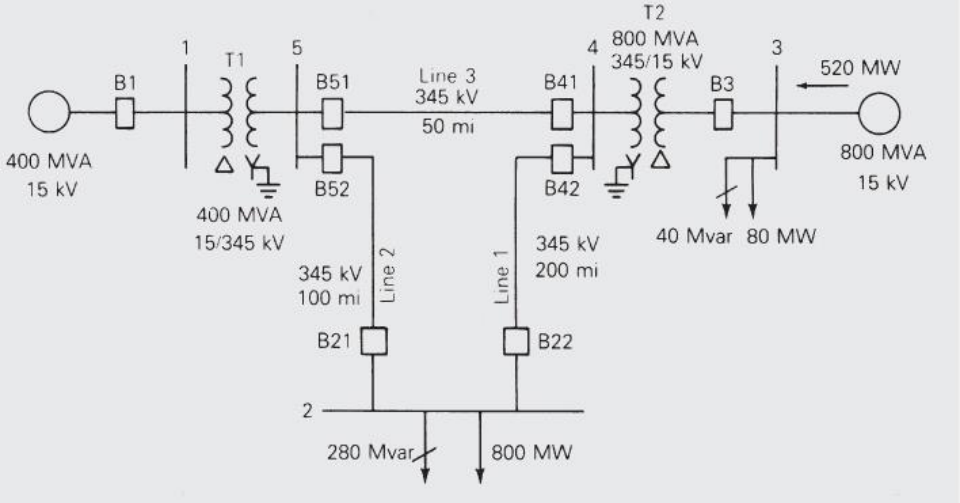
Simulation Project #1

Due date: 11/14/2023 (11:59 PM)

Please note:

- F.A. stands for Final Answer.
- Since the final answers are provided, you have to show your work no matter how simple the problem is.
- The Simulation project must be submitted electronically on Canvas.

1. The single line diagram of a five-bus power system is shown below. Machine, line and transformer data are given in the following tables. This system is initially unloaded. Prefault voltages at all buses are 1.05 per unit.



Single line diagram for the five-bus power system

TABLE 7.3

Synchronous machine data for SYMMETRICAL SHORT CIRCUITS program*

Bus	Machine Subtransient Reactance—X''_d (per unit)
1	0.045
3	0.0225

*S_{base} = 100 MVA
V_{base} = 15 kV at buses 1, 3
= 345 kV at buses 2, 4, 5

TABLE 7.4

Line data for SYMMETRICAL SHORT CIRCUITS program

Bus-to-Bus	Equivalent Positive-Sequence Series Reactance (per unit)
2–4	0.1
2–5	0.05
4–5	0.025

TABLE 7.5

Transformer data for SYMMETRICAL SHORT CIRCUITS program

Bus-to-Bus	Leakage Reactance—X (per unit)
1–5	0.02
3–4	0.01

a) Hand calculate the bus admittance matrix Y_{bus}. Clearly show how different elements of the bus admittance matrix are calculated. **(5 Points)**

b) Use the Y_{bus} to calculate the bus impedance matrix (Z_{bus}). **(5 Points)**

c) Use the appropriate elements of the Z_{bus} to calculate the fault current for three-phase faults at each of the buses. **(10 Points)**

d) Use the current-division rule to calculate the generators' contributions to the fault current ($I_{G_1}(F), I_{G_2}(F)$) for each fault (Convert the Δ-connected lines to its equivalent Y, if necessary). **(20 Points)**

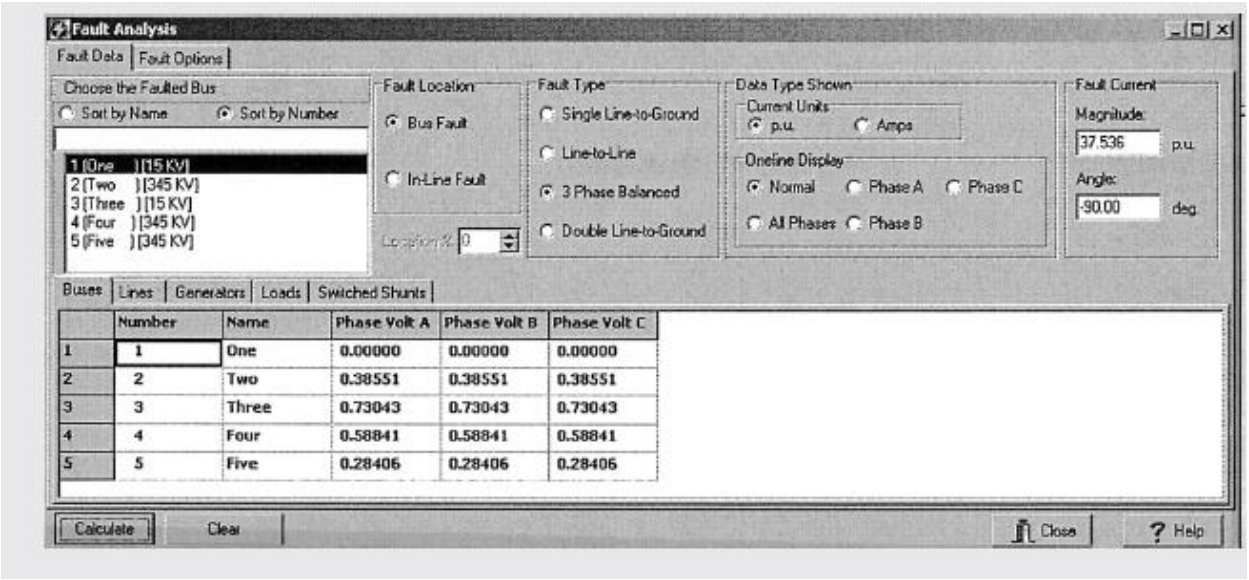
e) Use the Z_{bus} and the vector of bus injected currents to calculate the per-unit bus voltages during each fault ($V_1(F), V_2(F), V_3(F), V_4(F), V_5(F)$). **(20 Points)**

f) Build the five-bus power system in PowerWorld Simulator. **(10 Points)**

g) Use the power system that you built in PowerWorld Simulator for part (f) and confirm the results of parts c, d and e. Take screenshots of the dialog boxes and paste them here. **(30 Points)**

Guideline for fault analysis in PowerWorld Simulator:

To fault a bus from the one-line, first right-click on the bus symbol to display the local menu, and then select "Fault." This opens a dialog box where you will click on the "Single Fault" option on the top left to display the **Fault** dialog (see Figure below). Verify that the fault location is "Bus Fault" and the Fault Type is "3 Phase Balanced." Then select "Calculate," located in the top left corner of the dialog, to determine the fault currents and voltages. Take a screenshot of this dialog box to provide the confirmation for the results of parts c and e.



Then select "Generators," located above the fault voltages in the dialog to find the generators' contributions to the fault current. Take a screenshot of the dialog box to provide the confirmation for the results of part d.

Note: **<u>Your solution will include the screenshot of the fault currents and voltages as well as the screenshot of the generators' fault current contributions for faults at each of the buses.</u>**

(Total 5 screenshots for the fault currents and voltages and 5 screenshots for the fault current contributions)

You will turn in the electronic copy of your solutions for parts (a) to (g) and upload your PowerWorld files (both .pwb and .pwd) on Canvas.

F.A.

TABLE 7.6

Z_{bus} for Example 7.5

$$j\begin{bmatrix} 0.0279725 & 0.0177025 & 0.0085125 & 0.0122975 & 0.020405 \\ 0.0177025 & 0.0569525 & 0.0136475 & 0.019715 & 0.02557 \\ 0.0085125 & 0.0136475 & 0.0182425 & 0.016353 & 0.012298 \\ 0.0122975 & 0.019715 & 0.016353 & 0.0236 & 0.017763 \\ 0.020405 & 0.02557 & 0.012298 & 0.017763 & 0.029475 \end{bmatrix}$$

TABLE 7.7

Fault currents and bus voltages for Example 7.5

Fault Bus	Fault Current (per unit)	Contributions to Fault Current: Gen Line or TRSF	Contributions to Fault Current: Bus-to-Bus	Contributions to Fault Current: Current (per unit)
1	37.536			
		G 1	GRND–1	23.332
		T 1	5–1	14.204
2	18.436			
		L 1	4–2	6.864
		L 2	5–2	11.572
3	57.556			
		G 2	GRND–3	46.668
		T 2	4–3	10.888
4	44.456			
		L 1	2–4	1.736
		L 3	5–4	10.412
		T 2	3–4	32.308
5	35.624			
		L 2	2–5	2.78
		L 3	4–5	16.688
		T 1	1–5	16.152

$V_F = 1.05$ Fault Bus:	Per-Unit Bus Voltage Magnitudes during the Fault: Bus 1	Bus 2	Bus 3	Bus 4	Bus 5
1	0.0000	0.7236	0.5600	0.5033	0.3231
2	0.3855	0.0000	0.2644	0.1736	0.1391
3	0.7304	0.7984	0.0000	0.3231	0.6119
4	0.5884	0.6865	0.1089	0.0000	0.4172
5	0.2840	0.5786	0.3422	0.2603	0.0000